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(54) [Title] Melt processing method and melt process container

(57) [Claims]

[Claim 1] A melt processing method in which the object to be melt processed is placed in a container with a gas-permeable layer member on its inner wall surfaces,

the aforementioned object is melted inside the aforementioned container by flowing electrical current through said object, and

melt processing of the aforementioned object is performed while capturing gas produced in the process of the melting the aforementioned object.

[Claim 2] The melt processing method described in claim 1, characterized in that the aforementioned object is contaminated soil.

[Claim 3] The melt processing method described in claim 1 or 2, characterized in that the aforementioned object is soil that contains solids.

[Claim 4] The melt processing method described in any of claims 1 through 3, characterized in that the walls of the aforementioned container possess an inner layer comprising the aforementioned layer member and an outer layer that seals in gas produced in the process of melting the aforementioned object.

[Claim 5] The melt processing method described in any of claim 4, characterized in that the aforementioned inner layer is formed in a porous form.

[Claim 6] The melt processing method described in claim 4 or 5, characterized in that the aforementioned outer layer is formed of a material that possesses sealing properties with respect to the aforementioned gas up to at least the decomposition temperature of the substances contained in the aforementioned object.

[Claim 7] The melt processing method described in any of claims 1 through 6, characterized in that the aforementioned container is disposed inside an outer container that has been formed in the soil and
the space between the aforementioned container and the aforementioned outer container is filled with a filler.

[Claim 8] The melt processing method described in claim 7, characterized in that the aforementioned filler is clean soil.

[Claim 9] A melt process container in which an object is placed in order to melt process said object by flowing electrical current through the object, which melt process container is characterized in that it includes an inner layer comprising a gas-permeable layer member and an outer layer that has the function of sealing in gas produced from the aforementioned object.

[Claim 10] The melt process container disclosed in claim 9, characterized in that it includes an outer container that encloses the outer perimeter of the aforementioned walls and

the space between the aforementioned walls and the aforementioned outer container is filled with a filler.

[Claim 11] The melt process container disclosed in claim 9 or 10, characterized in that the aforementioned object is contaminated soil.

[Claim 12] The melt process container disclosed in any of claims 9 through 11, characterized in that the aforementioned object is soil that contains solids.

[Claim 13] The melt process container disclosed in any of claims 9 or 12, characterized in that the aforementioned inner layer is formed in a porous form.

[Claim 14] The melt process container disclosed in an of claims 9 or 13, characterized in that the aforementioned outer layer is formed of a material that possesses sealing properties up to the decomposition temperature of the substances contained in the aforementioned object.

[Claim 15] The melt process container disclosed in any of claims 10 through 14, characterized in that the aforementioned filler is clean soil.

[Detailed Description]

[0001]

[Pertinent Technical Field] This invention pertains to a melt processing method and melt process container, and specifically pertains to a melt processing method and melt process container that eliminate the effects gases, etc. produced with the melting of contaminants when using in-situ vitrification (ISV) technology to melt process soil-borne contaminants.

[0002]

[Prior Art] An environmental problem has recently intensified at abandoned factory and laboratory sites in which soil is contaminated by the effluents of hazardous chemical reagents and residues containing hazardous substances that were used at these facilities. Therefore, technologies have become necessary to restore this contaminated soil to its original condition or to remove the contaminants. A variety of research is underway for this purpose.

[0003] Amidst this, in-situ vitrification (ISV) technology is being developed as one of these countermeasures, which cleans contaminated soil by

melting and vitrifying the soil itself at the original site at which those contaminants exist in the soil. Therefore, Figure 3 shows the melt processing system procedure, which vitrifies the contaminated soil itself using this ISV technology.

[0004] As shown in Figure 3(A), first, an off-gas hood H is installed on the perimeter soil S1 in which contaminated soil S2 is present, which is the original site to be melt processed, so as to entirely cover the top of the contaminated soil S2, which is the object of remediation, and overlap onto clean soil. Furthermore, melt electrodes ME1 and ME2 are inserted into the clean topsoil. Next, a conductive low-resistance path R is laid between the melt electrodes ME1 and ME2 to facilitate the initial flow of electrical current.

[0005] The melt electrodes here are each rod electrodes made, e.g., from graphite to withstand high temperatures. In addition, ductwork is connected to the off-gas hood H to exhaust gas produced during the remediation process from the contaminated soil being cleaned to an off-gas treatment system.

[0006] Once the melt preparations are completed, electrical power supplied from a generator or the power grid is flowed to the melt electrodes ME1 and ME2. At this time, since there is a conductive low-resistance path R, Joule heat is generated along this low-resistance path R, which Joule heat melts the soil on and surrounding the low-resistance path, turning it to a magma form.

[0007] As shown in Figure 3(B), since the electrical resistance of the melted portion vastly decreases as the electrical current continues and the soil is melted, soil adjacent to the low-resistance path R is sequentially melted by the electrical power supplied from the melt electrodes ME1 and ME2, forming a melt zone MG. The melt zone MG sequentially expands from the top downward.

[0008] In response to this expansion of the melt, the melt electrodes ME1 and ME2 are further inserted downward. At this time, insertion of the melt electrodes is done so that the electrodes sink downward under their own weight according to the melting of the soil.

[0009] Thus, once melting has been completed to the extent that all the contaminated soil S2 requiring remediation has been included, the supply of electricity to the melt electrodes ME1 and ME2 is stopped. As shown in Figure 3(C), since the volume of the melt zone MG, in which the contaminated soil S2 has been melted, is decreased by 25 to 50%, from the viewpoint of its original state, the area of subsidence can be reburied with new soil S3.

[0010] Since treatment of one batch of the contaminated soil S2 to be cleaned is thus completed, the off-gas hood H can be moved to the next batch process.

[0011] With the ISV technology described above, decontamination processing can be accomplished in-situ using a portable facility. This facilitates the in-situ treatment of even contaminated soil that would be difficult to excavate. For contaminated soil that can be excavated, the soil can be placed in a special partition and melt processed inside that partition, and then reburied in clean soil, making it unnecessary to transport it to a separate location, such as a disposal site, etc.

[0012] In addition, by utilizing ISV technology to vitrify contaminated soil, e.g., heavy metals and radioactive substances, etc. in the soil can be melted and solidified sealed inside a vitrified mass, while insoluble hazardous organic substances, such as dioxins, etc., can be pyrolyzed and rendered harmless by the high 1,600 to 2,000°C temperatures when the soil is melted.

[0013] Furthermore, besides contaminated soil, it is also possible to batch process solids, such as incinerated ash, fireproof bricks, or drums, etc., and flammables, such as plastics, etc., in-situ. Moreover, vitrifying the soil not only enables melt processing to be performed that vastly reduces the volume of the soil, but also has the characteristic of being able to maintain long-term stability through vitrification.

[0014]

[Problems to be Solved] However, when utilizing ISV technology to melt process and vitrify contaminated soil or soil with embedded solids, etc., the contaminants and solids, etc. contained in the soil are burned, vaporized,

volatilized, or pyrolyzed, etc., to produce gases in the melting process. Since these off-gases contain trace amounts of hazardous constituents, an off-gas hood H that covers the contaminated soil that is the object of melt processing is installed as shown in Figure 3, so that these off-gases are not released into the atmosphere. The off-gases accumulated by the off-gas hood H are sent to an off-gas treatment device, passed through secondary heat treatment and filtering, etc., and then released to the atmosphere.

[0015] The production of gases during the melt processing of contaminated soil will be explained here, using the melt processing of contaminated soil S2 by ISV technology, as shown in Figure 3, as an example. Figures 4(A) through (C) show the conditions during the course of the melt processing in Figure 3(B).

[0016] Figure 4(A) shows the condition in which contaminated soil S2 is melted to form a melt zone MG, wherein the gases produced from the melt zone MG during the melt process are released primarily from the upper surface of the melt zone MG as off-gases a into the off-gas hood H. However, gases produced inside the melt zone MG during the melt process are not only the off-gases a, but are also diffused into the surrounding soil S1 that surrounds said zone as off-gases b that are diffused through the side and bottom surfaces of said zone. It is believed that these diffused off-gases b permeate the surrounding soil S1 and are released as off-gas c.

[0017] In addition, as shown in Figure 4(B), as the result of the surrounding soil S1 also being heated during the melt process, the surrounding soil S1 surrounding the melt zone MG may dry out and form a dry zone D. Because the soil itself is dried, this dry zone D is more gas-permeable than it was before drying. Because of this, while off-gases b exiting the melt zone MG spread into the surroundings of said zone MG, those off-gases b pass through this dry zone D and are released as off-gas d.

[0018] Thus, in the middle of melt processing contaminated soil S2, off-gases a through d are produced and released or diffused. However, these off-gasses contain hazardous constituents, as discussed above. Therefore, a and d of these off-gases are not problems because they are captured by the off-gas

hood H, but off-gas c is released directly into the atmosphere, as shown in Figure 4(A), producing a pollution problem. Furthermore, some of off-gas b becomes off-gas c, or may possibly remain in the surrounding soil S1 after the melt zone MG has cooled and, presuming that melt processing of the contaminated soil is performed in-situ, with the hazardous constituents remaining in the surrounding soil S1 there is a problem that the surrounding soil S1 will be contaminated even though the contaminated soil itself has been treated.

[0019] Meanwhile, if melt processing of the contaminated soil is performed in the rain, the rainwater will not directly contact the melt zone MG because the top of the area being treated is covered by the off-gas hood H capturing the off-gases. However, depending on the condition of the surrounding soil S1, rainwater may infiltrate the soil and reach the surroundings of the melt zone MG. In this kind of situation, some of the melting energy is consumed vaporizing the infiltrating rainwater, and extra power must be supplied from the melt electrodes ME1 and ME2. Therefore, there is a problem with poor melt efficiency, making it difficult to perform melt processing when it is raining.

[0020] Furthermore, the infiltration of water toward the melt zone MG is not only from rainwater, but there are also cases in which the contaminated soil S2 is near groundwater, as shown in Figure 4(C). In this case, moisture W from the groundwater gradually increases through the surrounding soil S1 toward the melt zone MG so that vast amounts of melt energy are consumed vaporizing this increasing moisture W. Moreover, this presents the problem of lengthening the melt processing time.

[0021] There are also cases in which the contaminated soil itself is damp soil, which must be melt processed, or in which solids, etc. have been buried, as described above, in damp soil and must be batch melt processed together with the soil. However, in these cases as well, melt energy is vastly consumed vaporizing the water contained in the damp soil, making the in-situ melt processing of contaminants difficult.

[0022] Therefore, the purpose of this invention is to provide a melt processing method and melt process container that do not diffuse gases produced from the melt zone into the surroundings and are not affected by water from the surroundings, and are therefore efficient and provide for preventing the contamination of surrounding soil.

[0023]

[Means of Solving Problems] In order to solve the aforementioned problems, with this invention, in a melt processing method melt processes an object, the object to be melted is placed in a container with a gas-permeable layer member on its inner wall surfaces, the aforementioned object is melted inside the aforementioned container by flowing electrical current through said object, and melt processing of said object is performed while capturing gas produced in the process of the melting the aforementioned object.

[0024] In addition, the aforementioned object is contaminated soil or soil that contains solids, the walls of the aforementioned container are equipped with an inner layer comprising the aforementioned layer member and an outer layer that seals in gas produced in the process of melting the aforementioned object, the aforementioned inner layer is formed in a porous form, and the aforementioned outer layer is formed of a material that possesses sealing properties with respect to the aforementioned gas up to at least the decomposition temperature of the substances contained in the aforementioned object.

[0025] Furthermore, the aforementioned container is disposed inside an outer container that has been formed in the soil and the space between the aforementioned container and the aforementioned outer container is filled with a filler, which filler is clean soil.

[0026] Additionally, with this invention, a melt process container, in which an object is placed in order to melt and then solidify said object by flowing electrical current through the object, is equipped with walls that include an inner layer comprising a gas-permeable layer member and an outer layer that has the function of sealing in gas produced from the aforementioned object.

[0027] It also includes an outer container that encloses the outer perimeter of the aforementioned walls and the space between the aforementioned walls and the aforementioned outer container is filled with a filler, and the aforementioned object is contaminated soil or soil that contains solids.

[0028] Furthermore, the aforementioned inner layer is formed in a porous form, [*the aforementioned outer layer*][1] is formed of a material that possesses sealing properties up to the decomposition temperature of the substances contained in the aforementioned object, and clean soil is used as the aforementioned filler.

[0029]

[Embodiment] An embodiment of the melt processing method and melt processing container of this invention, which melt processes and vitrifies contaminants together with soil, will be described below, referring to Figure 1 and Figure 2.

[0030] As shown in Figure 3 and Figure 4, in past contaminant vitrification, which performed melt processing using ISV technology, exploiting the characteristic of performing melt processing and vitrification in-situ, with the contaminants in their undisturbed state, melt electrodes were directly inserted into the contaminants to be melt processed in the surrounding soil, and electricity was supplied to them. Therefore, the contaminants were melted by the electricity, forming a melt zone in the soil, which melt zone was in a state in direct contact with the surrounding soil. This resulted in off-gases from the melt zone diffusing into the surrounding soil, or in the melt process being affected by the moisture contained in the surrounding soil.

[0031] Therefore, according this embodiment, a process container, which can accommodate the contaminants to be melt processed in a state isolated from the surrounding soil at the original site in which the contaminants are extant, is used in the melt processing of contaminants using ISV technology. Thus, a melt zone is formed inside this process container by supplying power to the contaminants from the melt electrodes.

[1] *Translator's note: The bracketed distinction, included in the corresponding claim, was omitted in this paragraph.*

[0032] Furthermore, the process container used in this embodiment is characterized in that it possesses an inner container and an outer container, which inner container is made from an inner layer and an outer layer, which inner layer is formed of a gas-permeable layer member, and which outer layer is formed of a material that has the function of sealing in gas produced from the contaminants to be melt processed.

[0033] The method of melt processing contaminants using ISV technology according to this embodiment is shown in Figure 1. An example is shown in Figure 1, as in Figure 3, in which contaminated soil S2 exists in clean surrounding soil S1. This contaminated soil S2 is to be melted and condensed by ISV technology. The difference in the melt processing method in Figure 1 from the past method in Figure 3 is that the contaminated soil S2 is melt processed after being placed inside a process container.

[0034] Next, a typical example of the procedure associated with the melt processing method of this embodiment will be explained. The contaminated soil S2 is embedded in surrounding soil S1, and this contaminated soil S2 cannot be excavated and transported to another location because of environmental protection concerns. Therefore, treatment of the contaminated soil S2 must in any case performed at the site where the contaminated soil S2 currently is, so that the process container described above must be installed in the area adjacent to said contaminated soil S2.

[0035] Therefore, first, the operation of installing the process container will be explained. A hole large enough to bury the outer container 1 of the process container is excavated in the surrounding soil S1 in which the contaminated soil S2 is embedded. The excavated clean soil is stored, and will later be used as backfill for this hole. This excavated clean soil may also be used as filler between the outer container and the inner container.

[0036] An outer container 1 is installed in this excavated hole. This outer container 1 is formed of plates made from a shielding material, such as steel, that is impervious to off-gases and/or moisture. This outer container 1 has the role of preventing the gases produced by the process of melting the

contaminated soil from diffusing into the surrounding soil S1, and preventing water from infiltrating from the surrounding soil S1 during said melt process.

[0037] If the volume of the contaminated soil S2 is known, a container manufactured in advance to fit that volume can be used as this outer container 1, or plate steel, etc. may be assembled at the site. In addition, once the outer container 1 has been installed inside hole, after packing some of the previously excavated clean soil CS into the bottom of the outer container 1, the inner container 2 is placed on top of this. Furthermore, the space formed between the outer container and the inner container 2 is then filled with previously excavated clean soil CS. The space between the outer container 1 and the inner container 2 is thus filled with excavated clean soil CS because it is assumed that the outer container 1 will be left in-situ together with the vitrified mass of contaminated soil at the processing site. Further, this clean soil CS may be some other filler, or may be recycled for the next melt process.

[0038] Installation of the process container in the surrounding soil S1 is completed when the outer perimeter of the inner container 2 is filled with clean soil CS, as shown in Figure 1. At this point, the contaminated soil S2 is excavated, and then this contaminated soil S2 is placed inside the inner container 2. Thus, the contaminated soil S2 is in the same state as when it is embedded in surrounding soil S1, as shown in Figure 3(A), after which, the contaminated soil S2 is backfilled over with clean soil. The difference in the case of this embodiment from that in Figure 3(A) is that the contaminated soil S2 is isolated in the surrounding soil S1 by the surrounding soil S1, the outer container 1, and the inner container 2.

[0039] By thus completing preparation of the contaminated soil S2 for melt processing, the entire top opening of the outer container is covered with an off-gas hood H, in the same manner as shown in Figure 3(A), the melt electrodes ME1 and ME2 are inserted, and a conductive low-resistance path R is laid between the melt electrodes ME1 and ME2. Melting of the contaminated soil S2 is then started by flowing electrical current between the melt electrodes ME1 and ME2. The subsequent melt processing is performed in the same manner as

in the past, sinking the melt electrodes ME1 and ME2 under their own weight, and melt processing is completed in the depth direction of the contaminated soil S2 when they reach the bottom of the inner container 2. As shown in Figure 1, the contaminated soil S2 becomes a melt zone MG inside the inner container 2. In this case, contaminated soil S2 contained inside an inner container 2 is melted, but the clean soil CS packed into the bottom of the outer container 1 is not melted.

[0040] The construction of the inner container 2 will be described here, referring to Figure 2. Figure 2 shows a magnification of a partial cross-section thereof. The wall of the inner container 2 is a composite layer made, e.g., from two layers, an inner layer 3 and an outer layer 4. The inner layer 3 and outer layer 4 may be affixed to one another, or they may be laminated together at the time installation. The inner layer 3 is formed of a member that is permeable to the gas b that is produced when the contaminants decompose and volatilize in the process of melting the contaminated soil S2. This gas-permeability can be achieved, e.g., by forming the layer of a porous material. Since this inner layer 3 is in contact with the contaminated soil S2, it is made so that the entire thickness of the layer does not melt and maintains its gas-permeability during the melt processing of the contaminated soil S2.

[0041] Meanwhile, the outer layer 4 is formed of a material that possesses sealing properties with respect to the off-gases up to at least the temperature at which the contaminants contained in the contaminated soil S2 decompose and volatilize. For example, it can be selected from a metal, such as aluminum or steel, etc. or composite ceramic, etc. according to the type of contaminant.

[0042] As shown in Figure 2, the inner container 2 is installed in contact with contaminated soil S2 on one side, and with the clean soil CS on one side. When the melt process is started on the contaminated soil S2, off-gases are produced accompanying that melting. At this time, off-gas a is produced that is directly released upward from the contaminated soil S2, and off-gas b is produced to the sides. Off-gas b is exhausted into the inner

layer 3, and then passes through the interior of the inner layer 3 and is released into the off-gas hood H.

[0043] Thus, when melt processing contaminated soil S2, a high-temperature melt zone MG is formed in the inner container 2 and, without melting, the entire inner layer 3 maintains its function of guiding off-gases b into the off-gas hood H. Even if the outer layer 4 were to be melted by the temperatures generated by the melt zone MG, at that point decomposition and volatilization of the contaminants will have already been completed. Therefore, it would not pose a problem even if the outer layer 4 were to melt at this point and lose its sealing properties with respect to the off-gas.

[0044] By installing the above kind of process container, as shown in Figure 1, and melt processing the contaminated soil S2 contained therein with ISV technology, said contaminated soil S2 can be rendered harmless and its volume can be condensed. Since, after melt processing, it becomes a harmless vitrified mass, it can be easily removed from the process container and its subsequent handling is simple. In addition, when contaminated soil is buried in large quantities, melt processing can be repeated in batches, sequentially excavating volumes to accommodate each batch-sized process container.

[0045]

[Effect] Since a process container with an inner container and an outer container to accommodate the contaminated soil is used in the contaminated soil melt process of this invention, as described above, no only can off-gases be prevented from diffusing out of the melt processing facility that contains the process container, off-gases can be prevented from diffusing into the surrounding soil or the atmosphere, preventing secondary contamination that would accompany the melt processing.

[0046] Furthermore, since a shielding material is used in the outer container, moisture or water can be prevented from infiltrating from the surrounding soil and melt processing can be performed without being affected by water, even at locations with a high water table and in wet zones. Thus, the electrical energy provided for melting can be efficiently utilized to treat contaminants.

[0047] In addition, by using an inner container comprising an inner layer and an outer layer, the decomposition gases produced in the process of melt processing can be effectively captured inside the off-gas hood. Moreover, when the off-gas contains organic compounds, since the flow path through which those gases pass can be limited to a high-temperature zone, the efficiency with which those organic compounds are rendered harmless can be improved.

[0048] The presence of the inner container makes it possible to clearly separate the field in which the vitrified mass is formed after melt processing of the contaminants from the field of sintered mass produced by combustion of the clean soil, minimizing the quantity of vitrified mass.

[Brief Explanation of the Figures]

[Figure 1] This is a lateral cross section in the soil to explain a embodiment of the melt processing method of this invention.

[Figure 2] This is a diagram that shows a magnification of a partial cross-section of the inner container used in this embodiment.

[Figure 3] This is a lateral cross section to explain an example application of the past melt processing method by in site vitrification (ISV) technology.

[Figure 4] This is a diagram to explain the effects of off-gases, etc. in the past melt processing method.

[Legend]

1 … outer container

2 … inner container

3 … inner layer

4 … outer layer

a-d … off-gases

CS … clean soil

H … off-gas hood

ME1, ME2 … melt electrodes

MG … melt zone

S1 … surrounding soil

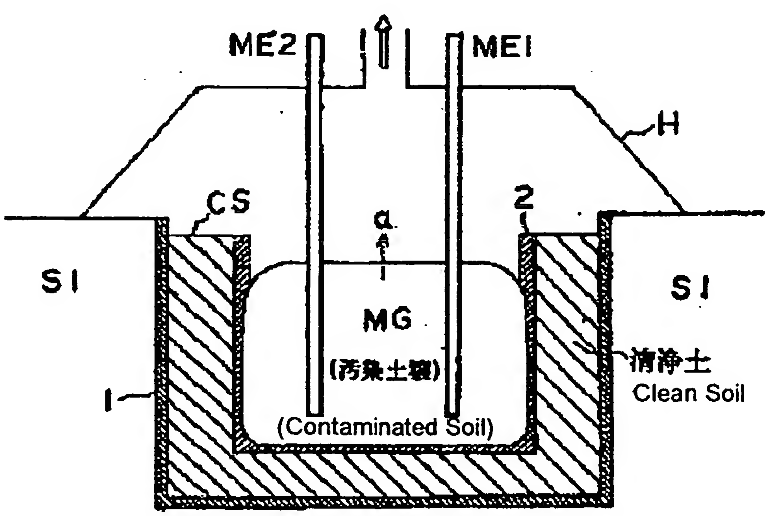
S2 … contaminated soil

[Abstract]

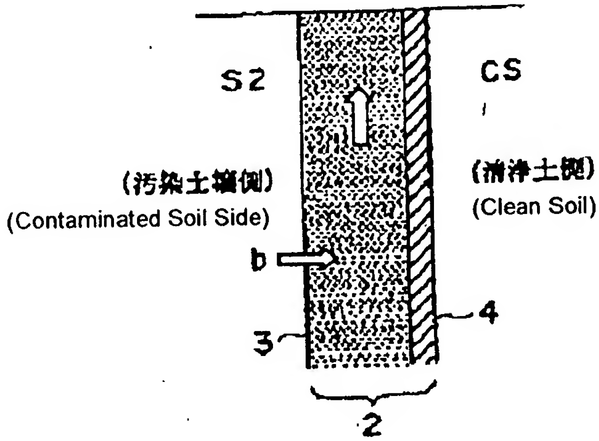
[Problem] The purpose of this invention is to provide a melt processing method and melt process container that prevent the diffusion of gases produced from the melt zone into the surroundings and prevent the effects of water from around the process when melt processing contaminated soil, and thereby improve energy efficiency efficient and provide for preventing the contamination of surrounding soil.

[Means of Solution] A shielding outer container 1 is buried in the soil, and an inner container 2 is disposed inside said container with clean soil CS in between. Contaminated soil is placed in the inner container, and then electrical current is flowed between electrodes ME1 and ME2 to melt process the contaminated soil and produce a vitrified mass. The inner container is constructed of a porous, gas-permeable inner layer and an outer layer that has sealing properties with respect to the off-gases up to the temperature at which the contaminants decompose and volatilize. In addition to traveling the path in the direction a, the gases produced in the process of melt processing the contaminated soil S2 also pass through the inner layer and are released into an off-gas hood H.

[Fig. 1]

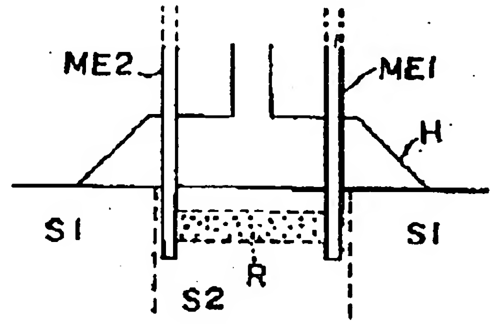


[Fig. 2]


S2
CS
(汚染土壌側)
(Contaminated Soil Side)
(清浄土側)
(Clean Soil)
b
3
4
2

[Fig. 3]

(A)



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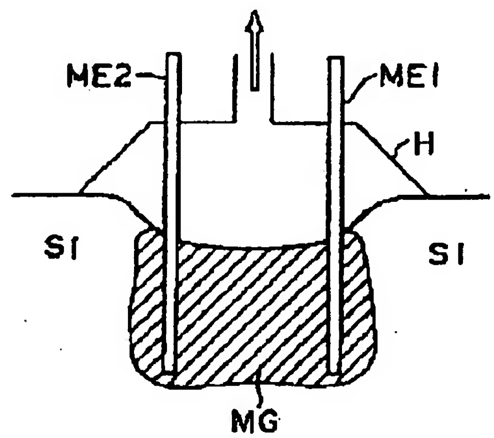
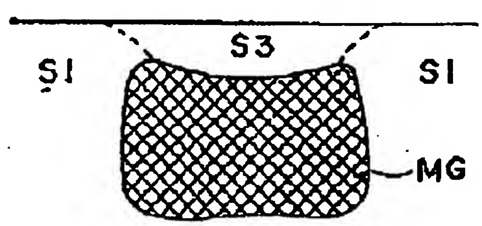
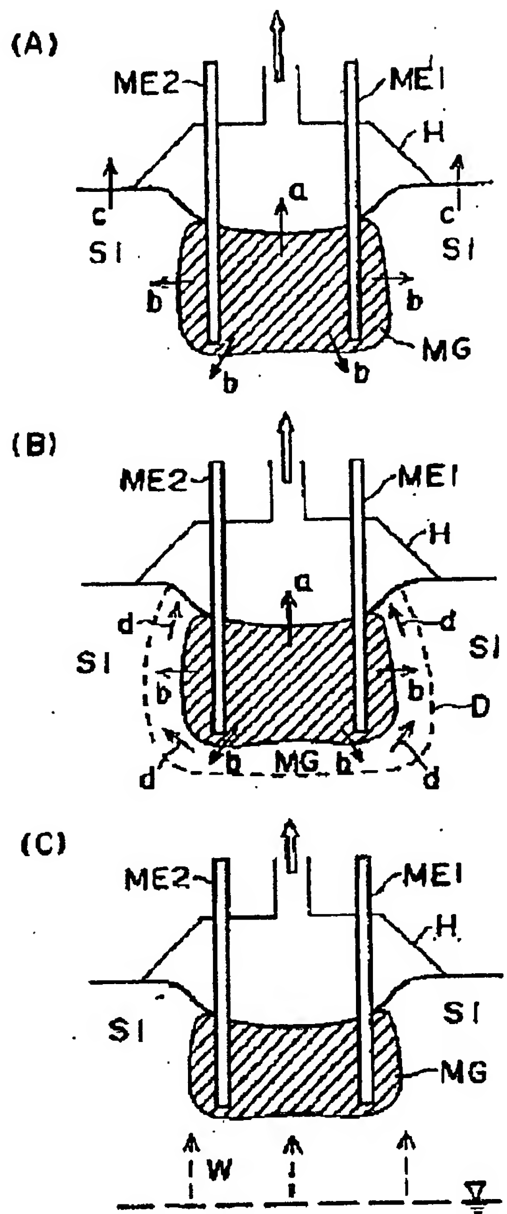


(C)



[Fig. 4]


(A)
ME2
ME1
H
a
c
c
S1
S1
b
b
b
b
MG
(B)
ME2
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H
a
d
d
S1
S1
b
b
D
d
b
MG
b
d
(C)
ME2
ME1
H
S1
S1
MG
W

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(58) Examined Fields (Int. Cl.[7], DB Name)

B09C 1/06

E02D 3/11

JICST File (JOIS)

WPI (DIALOG)